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Intensive care utilization and outcomes after high-risk surgery in Scotland: a population-based cohort study

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Abstract

Background. The optimal perioperative use of intensive care unit (ICU) resources is not yet defined. We sought to determine the effect of ICU admission on perioperative (30 day) and long-term mortality.

Methods. This was an observational study of all surgical patients in Scotland during 2005–7 followed up until 2012. Patient, operative, and care process factors were extracted. The primary outcome was perioperative mortality; secondary outcomes were 1 and 4 yr mortality. Multivariable regression was used to construct a risk prediction model to allow standard-risk and high-risk groups to be defined based on deciles of predicted perioperative mortality risk, and to determine the effect of ICU admission (direct from theatre; indirect after initial care on ward; no ICU admission) on outcome adjusted for confounders.

Results. There were 572 598 patients included. The risk model performed well (c-index 0.92). Perioperative mortality occurred in 1125 (0.2%) in the standard-risk group (n=510 979) and in 3636 (6.4%) in the high-risk group (n=56 785). Patients with no ICU admission within 7 days of surgery had the lowest perioperative mortality (whole cohort 0.7%; high-risk cohort 5.3%). Indirect ICU admission was associated with a higher risk of perioperative mortality when compared with direct admission for the whole cohort (20.9 *vs* 12.1%; adjusted odds ratio 2.39, 95% confidence interval 2.01–2.84; $P<0.01$) and for high-risk patients (26.2 *vs* 17.8%; adjusted odds ratio 1.64, 95% confidence interval 1.37–1.96; $P<0.01$). Compared with direct ICU admission, indirectly admitted patients had higher severity of illness on admission, required more organ support, and had an increased duration of ICU stay.

Conclusions. Indirect ICU admission was associated with increased mortality and increased requirement for organ support.

Trial registration. UKCRN registry no. 15761.

Key words: epidemiology; intensive care; surgery

Latest estimates suggest that more than 310 million people undergo surgery worldwide each year,[1] and there is evidence that improvements in surgical care have led to a reduction in mortality after surgery in recent decades.[2–4] Estimates of hospital mortality after surgery range from 1 to 4%, but postoperative complication rates of up to 10 times this figure have been reported, and these influence long-term survival.[5] Variation in outcome remains, particularly in high-risk surgery. This phenomenon has been reported between and within nations[6 7] and between hospitals.[8 9] Incidence and outcome after postoperative complications have also been shown to differ

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Editor's key points

- High-dependency and intensive care beds are limited in many parts of the world.
- Unplanned admission to intensive care is a well-validated clinical indicator of quality and safety.
- This study found a strong association between unplanned admission to intensive care with both short- and long-term mortality.
- Routine preoperative identification of those most at risk of serious postoperative complications should lead to a direct admission to intensive care.

between hospitals, suggesting that institutional factors may be implicated.[8–10] Historically, reduced access to intensive care resources has been cited as a reason for variation in outcome after surgery.[11]

Identifying the patients at highest risk of dying or developing major complications in the postoperative period remains a major challenge. There is evidence that the proportion of patients who die from postoperative complications varies between hospitals; the so-called 'failure-to-rescue' group.[8] Thus, routine postoperative admission to critical care after many types of high-risk surgery has long been regarded as an important standard of care;[11] however, little evidence to support this exists and that which does is conflicting.[7 9 12] There is great interest in identifying which groups of patients are likely to benefit from use of perioperative critical care and whether it offers advantages over standard care after major surgery. The effect of intensive care unit (ICU) admission on postoperative outcome is not something that can easily be tested in a clinical trial, hence the reliance on observational studies.[13]

High-quality, linked data are available for all patients treated in National Health Service hospitals in Scotland. We sought to use these data to describe the patient characteristics and short- and long-term outcomes of all patients in Scotland undergoing non-cardiac surgery, to explore factors associated with greater risk of death, and to describe current use of intensive care services in Scotland for surgical patients. In particular, we wished to determine the association between mortality and direct admission to the ICU compared with patients admitted to the ICU after a period of care on the ward.

Methods

Ethics, sponsorship, and indemnity

The Chairs of South East Scotland Research Ethics Committees 01 and 02 reviewed the study protocol and waived the need for a full ethics submission. The study underwent review by Information Services Division's (ISD) Privacy Advisory Committee, which undertakes the role of Caldicott guardianship (Reference PAC 58/11).

Study population and data sources

We used a cohort study design with data held by ISD Scotland. These data are complete, linked, comprise all hospital and ICU admissions in Scotland, and have a low incidence of missing data.[14 15] Further details of the linkage process are available in the online supplementary material. We extracted a complete record of surgical inpatients managed in Scotland between January 1, 2005 and December 31, 2007 from the ISD Scottish Morbidity Record (SMR01) database. All adult patients undergoing inpatient general surgery were eligible for inclusion in this study. The Operating Procedure Coding System-4.2 (OPCS)[16] was used to identify general surgical procedures. We excluded cardiac and neurosurgical procedures because these patients all have established patient pathways or are managed in specialist centres. In addition, we excluded admissions involving endoscopy, organ transplantation, obstetrics, or the surgical management of burns. For patients with more than one included surgical procedure during the 3 yr study period, we used only the first surgical procedure.

Variables

For each patient, a full data extract was requested, including: age; gender; socio-economic status; surgical OPCS code; diagnosis on admission to hospital [using International Classification of Diseases, 10th Edition (ICD-10) code]; surgical status (elective *vs* emergency classification); and number of hospital admissions in the 5 yr before the index hospital admission. The OPCS codes and ICD-10 codes were grouped based on frequency. In addition, we reported a measure of co-morbidity using a count of co-morbidities that constitute the Charlson co-morbidity index, a measure of co-morbidity derived from 17 chronic conditions.[17] This approach has been used in other investigations.[18] Socio-economic status was assigned using quintiles of the Scottish Index of Multiple Deprivation (SIMD), which is based on area of residence and comprises multiple domains of differentially weighted measures of deprivation, including income, employment, education, crime, and housing.[19] Operative severity was assigned to each procedure using the 'BUPA Schedule of Procedures'.[20] BUPA operative severity and emergency surgical status are used in 'Physiological and Operative Severity for the Enumeration of Morbidity and Mortality' (POSSUM), a widely used risk prediction tool for comparative surgical audit.[21] We ascertained admission to an ICU by linkage to the Scottish Intensive Care Society Audit Group (SICSAG) database and obtained ICU-specific variables for those admitted to the ICU, as follows: severity of illness score on ICU admission [measured by Simplified Acute Physiology Score II (SAPS II)]; SAPS II-predicted mortality; requirement and duration of organ support (mechanical ventilation, renal replacement therapy, and cardiovascular support); ICU length of stay; and ICU mortality. Patients were classified by the main exposure variable as follows: those not admitted to ICU during the first 7 days after surgery ('no ICU admission'); those whose ICU admission occurred immediately after surgery (i.e. transferred directly from theatre or recovery room to ICU, 'direct ICU admission'); and those who were admitted to the ICU after $\leq$7 days in a non-ICU environment after surgery ('indirect ICU admission').

The primary outcome measure was death within 30 days of the procedure (perioperative mortality). Secondary outcomes were 1 and 4 yr mortality and duration of hospital admission. The 4 yr follow-up was assumed to be complete for all patients. Scottish national statistics indicate that the population has low levels of emigration; ~1.3% in total and 0.7% in those aged >35 yr.[22]

Statistical analysis

Univariable analyses were done to test the association of patient and operative factors with mortality at 30 days and 1 and